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(54) **Cast-in-place iron-based cylinder liners.**

(57) A cast-in-place liner construction useful in low pressure casting of hollow aluminium parts. The construction has an iron-based cylindrical body with a surface (10) thereof imprinted with a repeating pattern of crossed groups (12,13) of relief grooves (14), each groove (14) forming a helix along such surface, the spacing between such grooves and the depth of such grooves being uniformly controlled to permit the grooves to act as molten aluminium runners during low pressure casting of the aluminium that facilitates laying-up of the aluminium along the entire surface. Also, a method of deploying such liner, comprising : (a) imprinting a cylindrical surface of a sleeve designed to interface with cast aluminium thereagainst, the imprinting providing a quilted pattern of shallow crossing grooves sized and spaced to promote transfer of molten aluminium during low pressure filling of the mould containing such sleeve ; and (b) planting the liner in such mould and introducing aluminium thereagainst at a low pressure to form a desired aluminium casting.

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This invention relates to cast-in-place iron based liners and a method of casting an aluminium cylinder block having such liners

The bonding of iron-based elements to a surrounding mass of lighter weight metal has been a continuing problem for products that are subject to high operating temperatures such as an aluminium internal combustion engine block having iron-based liners.

The prior art has followed essentially one of two paths for solving the problem: metallurgical bonding or mechanical bonding. Metallurgical bonding, although it is not thoroughly understood, has proved unsuccessful possibly because the lighter weight metal, such as aluminium, has a strong tendency to chill and form an oxide film at the interface in at least some minor zone. In complex castings, such as aluminium engine blocks having intricately-shaped water jackets and a number of thin- walled cylinder walls, the ability to keep the aluminium at a sufficiently high temperature, at 100% of the interface with a liner, is extremely difficult. As the aluminium fully solidifies, it moves away (shrinks) and thus delaminates in at least such minor zone. As a result, there is a degraded heat transfer characteristic for the block that prevents such technique from being used commercially. At best, there is only 80-85% lay-up of the aluminium along the iron-based liner interface wall.

For metallurgical bonding, intermediate coatings of zinc alloys (see U.S. patent 2,634,469) have been suggested, but have been economically unsatisfactory for large-scale production of engine blocks.

As a hybrid, some form of mechanical bonding has been attempted by the prior art to add to the resulting metallurgical bond that may be attained. In one example (U.S. patent 3,069,209), the interfacing surface of the casting iron liners has been roughened by spiny protrusions when such liners are initially formed by casting; such protrusions act as longitudinal and circumferential mechanical bonds when aluminium is cast under high pressure (die-cast) therearound. High pressure is always required to move the aluminium across such protrusions and still achieve lay-up of aluminium against the original outer wall of the liner. The machined smooth wall of the liner becomes the valleys between the protrusions. Because of the need for quick high pressure mould filling to prevent premature freezing, such technique is impractical when casting aluminium engine blocks by low pressure (in the range of 2-5 psi), and mould filling times take an average of one-half minute.

In another hybrid example (U.S. patent 3,401,026), an irregular outer surface of a cast iron liner for an aluminium brake drum was used to augment any cylindrical bond existing by casting the liner in place. There was no disclosure of the type of irregular surface employed, but there was considerable disclosure as to the need for high sonic vibration of the molten aluminium during casting to create an intensive cavitation field that forces aluminium along the irregular surface to achieve good wetting. Such vibratory apparatus would be impractical for casting an aluminium engine block with a multiplicity of internal liners.

What is needed is a method that achieves essentially 100% lay-up of the molten aluminium against the outer surface of the iron-based liner cast-in-place within an aluminium block by low pressure casting techniques, such method not requiring any extra coatings or special equipment during casting to achieve such result.

In a first aspect, the invention is a cast-in-place liner construction useful in low pressure casting of hollow aluminium parts, the construction is characterised by an iron-based cylindrical body having a surface thereof imprinted with a repeating pattern of crossed groups of relief grooves, each groove forming a helix along such surface, the spacing between such grooves and the depth of such grooves being uniformly controlled to permit the grooves to act as molten aluminium runners during low pressure casting of the aluminium that facilitates laying-up of the aluminium along the entire surface.

The grooves advantageously will have a depth in the range of .02-.04 inch; the spacing between grooves is advantageously .20-.30 inch; and a width for each of such grooves in the range of .02-.04 inch. Preferably, the included angle between intersecting groups of grooves is in the range of 35-55°. Preferably, the imprinted surface is the outer cylindrical surface of the liner while the inner cylindrical surface thereof is smooth.

A second aspect of this invention is a casting method deploying such liner, the method comprising: (a) imprinting a cylindrical surface of a sleeve that is designed to interface with cast aluminium thereagainst, the imprinting providing a quilted pattern of shallow grooves, such grooves being sized and spaced to promote transfer of molten aluminium during low pressure filling of the mould containing such sleeve; and (b) planting the liner in such mould and introducing aluminium thereagainst at a low pressure to form a desired aluminium casting.

The imprinting may be carried out by machining the prefabricated sleeve or by imprinting indentations in the sleeve during rolling or fabrication of such sleeve.

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which :

Figure 1 is a perspective view of an iron liner embodying the principles of this invention;

Figure 2 is an enlarged view of the groups of grooves taken along the circled zone A of Figure 1;

Figure 3 is an enlarged sectional view taken ra-

dially through the wall of the liner; and

Figure 4 is a sectional elevational view of a V-configuration aluminium block for an internal combustion engine showing the liners cast according to the method of this invention.

Casting in place of iron cylinder liners in an aluminium cylinder block is considered routine when the block is produced by high pressure die casting. Molten metal is injected under high pressure and for a short period of time to facilitate the lay-up of the aluminium against the iron liner. However, for casting processes such as gravity or low pressure where mould filling occurs over a relatively long period and takes place with little or no pressure, the casting-in-place of liners is considered extremely difficult. This invention provides for a unique quilted pattern of grooving on the surface of the iron liner that is to interface with the aluminium, such pattern promoting the flow of molten aluminium against the iron cylinder bore liner surface to overcome the problem of chilling and accompanying oxide formation.

The iron-based liner 20 has a cylindrical body B provided with an outer surface 10 and an inner cylindrical surface 11, and a pattern C imprinted onto the outer cylindrical surface 10, which pattern is comprised of crossed groups 12 and 13 of relief grooves 14. The grooves are effective to uniformly act as molten aluminium runners during low pressure casting to facilitate laying-up of the aluminium along the entire cylindrical surface 10.

The grooves create a diamond-shaped pattern as criss-crossed, the lateral spacing 15 between adjacent grooves being on the order of .20-.30 inch, the depth 16 of each of the grooves being in the range of .02-.04 inch, and the width 17 of each of the grooves being desirably in the range of .02-.04 inches. The included angle 18 between intersecting or crossing grooves is in the range of 35-55°.

The pattern is imprinted on the outer cylindrical surface by either machining such pattern as the sleeve is rotated, or the pattern may be formed by indentations in the liner during rolling or casting of the liner itself. The grooves in each of the groups are helical about the outer surface of the liner; this is advantageous when placing the liner in an oblique position such as shown in Figure 4 for a V-shaped configuration aluminium block. In such application, one set of grooves will be somewhat horizontal with respect to a vertical plane 21 and the other set of grooves will be closer to the vertical plane as they wrap around the outer surface of the liner.

A casting method deploying such liners comprises: (a) imprinting a cylindrical surface of a iron-based sleeve designed to interface with a cast aluminium thereagainst, the sleeve having a quilted pattern of shallow grooves with the grooves sized and spaced to promote transfer of molten aluminium during a low pressure filling of a mould containing the sleeve; and (b) planting the liner in such mould and introducing aluminium thereagainst at a low pressure to form the desired aluminium casting. The pressure employed in such method is in the range of 2-5 psi and the temperature of the molten aluminium will be in the range of 1275°F. Due to the pattern of the grooves and their critical sizing, the molten aluminium will not drop below a fluid temperature during filling of the mould and will not prematurely freeze in migrating throughout all of the interstices of the cylindrical surface of the liner.

If the grooves are defined to have a depth in excess of .04 inch, there will be a tendency for the aluminium to freeze or form a miniscus characteristic of problems associated with the prior art. If the depth of the grooves is less than .02, there is little likelihood that a molten aluminium runner effect will be created. If groove spacing is greater than .3 inch, the ability to lay aluminium throughout the normal cylindrical surface is hindered, whereas a spacing between grooves of less than .20 inch will create difficulty in filling all the grooves with molten aluminium because of the lack of pressure driving the aluminium through such an increased maze of grooves. The ultimate effect of this invention achieves essentially 100% lay-up of aluminium against the iron- based liner after the completion of the low pressure casting technique. By "lay-up" it is herein meant: the amount of intimate contact between the outer surface of the iron liner and the aluminium barrel that surrounds the liner.

## Claims

1. A cast-in-place iron-based liner useful in low pressure casting of hollow aluminium parts, the construction comprising, an iron-based cylindrical body (B) having a cylindrical surface (10) imprinted with a repeating pattern (C) of crossed groups (12,13) of relief grooves (14), the path of each groove being a helix about said surface (10), the spacing between said grooves (14) and the depth of said grooves being uniformly controlled to permit the grooves to act as molten aluminium runners during such low pressure casting facilitating laying-up the aluminium along substantially the entirety of said surface.

2. A liner as claimed in claim 1, in which said grooves each have a depth in the range of .02-.04 inch.

3. A liner as claimed in claim 1, in which said grooves are spaced from each other a distance in the range of .5- .75cm (.20-.30 inch).

4. A liner as claimed in claim 1, in which the included angle between intersecting groups of grooves is in the range of 35-55°.

5. A liner as claimed in claim 2, in which the width of each of said grooves is in the range of .05-.1cm (.02-.04 inch).

6. A liner as claimed in claim 1, in which said imprinted surface is the outer cylindrical surface of said liner, and the inner cylindrical surface is smooth.

7. A liner as claimed in claim 1, in which said imprinted pattern achieves a quilted appearance.

8. A method of casting an aluminium cylinder block having cast-in-place iron-based liners, comprising:
   (a) imprinting a cylindrical surface on each of a plurality of cast iron-based sleeves, each sleeve being designed to interface with cast aluminium thereagainst, each sleeve having a quilted pattern of shallow grooves sized and spaced apart to promote transfer of molten aluminium during low pressure filling of the mould containing said sleeve; and
   (b) planting said sleeve in a mould and introducing aluminium thereagainst at a low pressure to form a desired aluminium casting.

9. A method as claimed in claim 8, in which the imprinting of step (a) is carried out by machining the cylindrical surface of the prefabricated sleeve or by forming indentations in the sleeve cylindrical surface during rolling or casting to fabricate the sleeve

10. A method as claimed in claim 8, in which the cylindrical surface of said sleeve is the outer surface thereof and the pattern of grooves extends throughout the entire outer surface to achieve essentially 100% lay-up of aluminium against such surface during step (b).

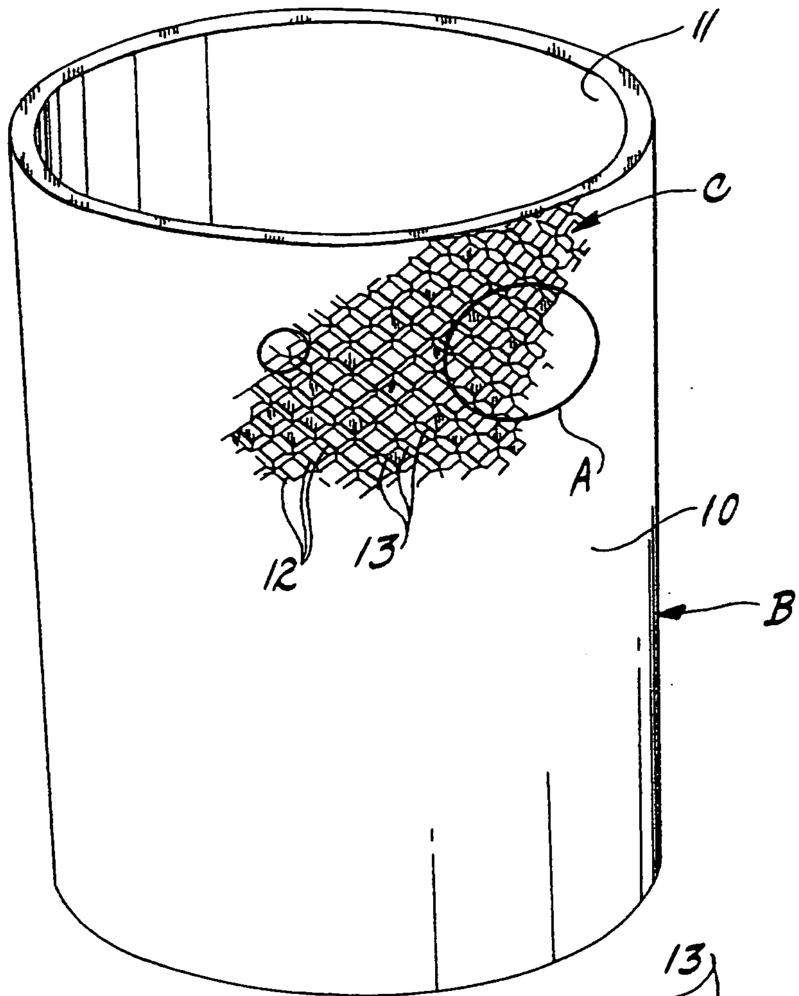


Fig. 1

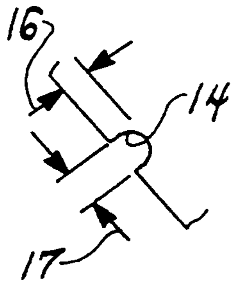


Fig. 3

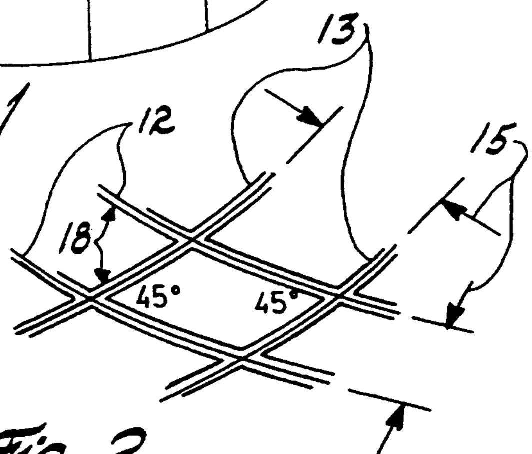


Fig. 2

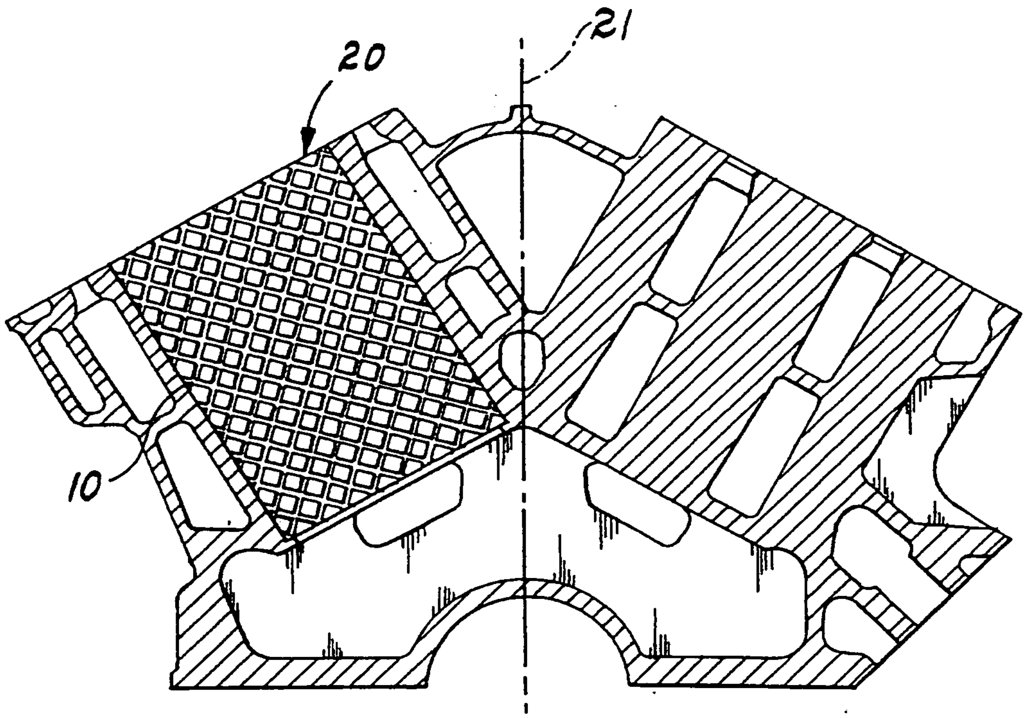


Fig. 4

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number

EP 92 30 8259

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| Y | FR-A-450 434 (M. ANTHELME GIREL)<br>* the whole document *<br>--- | 1,6,8 | B22D19/00 |
| P,Y | EP-A-0 491 978 (AUDI AG)<br>* claims; figures *<br>--- | 1,6,8 | |
| A | GB-A-873 012 (ALUMINUM COMPANY OF AMERICA)<br>* claims; figures 1,3 *<br>--- | 1,8 | |
| D,A | US-A-3 401 026 (JAMES B. WALKER)<br>--- | | |
| D,A | US-A-3 069 209 (ALFRED F. BAUER)<br>----- | | |

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B22D
F02F

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 16 DECEMBER 1992 | HODIAMONT S. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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